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THE TACTUAL PERCEPTION OF FORM

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This study endeavors in a somewhat preliminary and schematic way to throw light upon three related problems: (1) the degree of accuracy with which observers can render judgments as to the form, or shape, of certain common geometrical figures applied to the skin with vision excluded; (2) the psychological processes involved in the perception of tactual form and in particular the more salient features by which the forms of these figures are primarily apprehended; and (3) the rough determination of that magnitude of stimulus around which the threshold for the perception of these forms lies.

We used 5 straight-sided plane figures as stimuli: square, equilateral triangle, right-angled triangle, diamond, and hexagon. In our initial work, these were cut from cardboard and mounted upon a wooden handle which was convenient for manual application.[1] In every one of these figures the main dimension (the sides of the square and diamond, the altitudes of the triangles and the separation of the parallel sides of the hexagon) measured 20 mm. In subsequent work, and in particular for the performance of the third task, we used a series of 5 stimuli for every one of the figures named above. The main dimensions of the 5 members of every series were 5, 10, 15, 20 and 25 mm. These were cut from hard rubber. The threaded end of a brass handle could be screwed into a hole in the mid-point of every one of these stimuli. In order to insure a fair uniformity of intensity of application, the central rod of the handle passed through and worked against a small spiral spring, which was enclosed in the housing of the handle. A small slot running lengthwise in the wall of the handle-housing allowed an indicator, which was attached to the central rod, to protrude so that *E* could apply all stimuli at a uniform and determinate intensity. The intensity of application used was roughly 500 grm.

The *O*s include 3 undergraduates in advanced laboratory classes, Miriam Arrowsmith (A), Helen Land (L), Kathryn Ward (W) and the senior author of this study (Z). The stimulus was applied to the volar surface of the left forearm at a point about midway between the wrist and elbow. The stimulated member was passive throughout the application and was at all

[1]M. Carnes and L. C. Shearer, this Journal, 27, 1916, 417 ff., demonstrated that careful manual application insures practically as good results as mechanical application.

times screened from *O*'s eyes. The instructions read: "After the 'ready' signal a tactual stimulus will be applied to the volar surface of your forearm. You are to observe carefully and report the shape of the tactual impression and all observable criteria upon which your perception of shape is based." None of the *O*s, except Z, had any knowledge of the figures used. The results of our work upon the three questions follow.

TABLE I[2]

O	CLASS	Square	Equil. Triangle	Right Triangle	Diamond	Hexagon
A	Accurate	25	25	42	12	
	Confused	33	25	17	12	
	Inaccurate	33	33	29	54	92
	No Shape	8	17	12	21	8
L	Accurate	37	25	29		
	Confused	46	29	29	12	
	Inaccurate	12	42	33	83	100
	No Shape	4	4	8	4	
W	Accurate	21	29	37		
	Confused	21	12	21	8	
	Inaccurate	50	50	37	83	92
	No Shape	8	8	4	8	8
Z	Accurate	29	29	54	50	8
	Confused	8	12	33	12	12
	Inaccurate	46	46	8	29	71
	No Shape	12	12	4	8	8

I. THE ACCURACY OF TACTUAL PERCEPTION OF FORM

After a short preliminary period of training the 5 cardboard stimuli were presented in haphazard order to every *O* 24 times to ascertain the accuracy and definiteness of tactual perceptions of form under our conditions of experimentation. The results of this work are tabulated below in four classes: (1) Accurate Perception: form was accurately perceived and reported without qualification; (2) Confused Perception: uncertain perception where *O* reported the true form of the stimulus as well as an incorrect form, but was unable to say positively that a mature and determinate form was perceived; (3) Inaccurate Perception: the report of a form different from that which was applied; and (4) No Perception: where the tactual impression failed to take an observable form. Table I shows the percentages of these several kinds of perceptions given by all *O*s and for all figures.

[2]The percentages in the table are not carried beyond 2 places. Where a fraction exceeds ½ a unit is added, otherwise the fraction is dropped. The dropping of small fractions accounts for the loss of a unit in several columns.

The relative fewness of accurate perceptions is one of the outstanding results. Only one *O* secured as high as 50% accuracy of perceptions, and this was Z, who knew what stimuli were being used, so that he was more likely than the other *O*s to limit his judgments to the 5 figures used. The other *O*s were much more inclined to give a more extended variety of forms, such as: oval, circle, oblong, half circle, straight line. Three *O*s did not mention 'hexagon' throughout the experiment. It was perceived as such only by Z who worked with partial knowledge, and by him very infrequently. It usually gave rise to a perception of square, circle or oblong. The diamond also was difficult for several *O*s. It was reported by them very rarely and was usually confused with the triangles. The right-angled triangle, except in the case of one *O*, secured the highest percent of accurate judgments. The hypotenuse connecting the two acute angles and running diagonally across the forearm constituted a fairly dependable landmark for the accurate perception of this form.

Another item of interest is the fact that, in spite of the instruction to observe the shape of the tactual impression, all *O*s were often unable to perceive any shape at all, not even enough to warrant a guess—and this for practically every stimulus. The vague and indefinite perceptions are not confined to the fourth class in the table. The instructions demanded a report of shape, so that the *O* was inclined to guess even when the impression of form was so vague that only a pressure blur was perceived. These guesses fell into the inaccurate and confused classes; consequently, the perceptions in both of these classes may be taken as instances of indefinite perception of shape.

To assure ourselves that the stimuli were not too small for the facile perception of shape, we next ran through a brief series of experiments in which the main dimension of the stimuli was 35 mm. The outcome of this work, in spite of possible improvement as a result of practice, was, in the case of every *O* and for every stimulus, less (and in most cases markedly less) accurate than in the previous work. Because the larger stimuli were applied necessarily to a convex surface, they did not make so definite an impression along the contour of the stimulated field.

The most frequently confused and inaccurate judgments for the several stimuli were, in order of frequency: *square*—oblong, circle and oval; *equilateral triangle*—other triangles, semicircle, diamond and square; *right-angled triangle*—other triangles, diamond, oblong, square and oval; *diamond*—triangle, oval, oblong and square; *hexagon*—square and circle with about equal frequency.

II. Qualitative Aspects of the Tactual Perception of Form

When form is most clearly given, tactual processes alone carry the meaning of the particular shape. A definite and complete form, however, was the exception rather than the rule in our experiment. The more typical reports of all *O*s show that shape is not usually mediated by tactual processes only. Usually certain salient and discrete features of a figure, *e.g.* three disconnected angles of the equilateral triangle, two acute angles of the diamond, two straight parallel sides of the square, were definitely given in terms of sensory tactual processes but the incorporation of these salient features into a meaningful shape was as a general rule carried in imagery. Visual imagery was most frequently reported but sometimes the completion was made in something like a tactual tied-image, the *O* asserting that parts of the figure outline were not given in sensory tactual processes but in tactual imagery.

The salient features[3] of the several figures most frequently mentioned, given in the order of frequency, were as follows. *Square:* (1) two parallel sides, usually those running transversely to the arm; (2) pressure pattern of vague contour but having dimensions perceptually equal transversely and longitudinally; (3) two or more right angles. *Equilateral triangle:* (1) three acute angles or points; (2) an acute angle with sides of variable length and a straight line on opposite side of figure; (3) two sides and an angle or point; (4) three sides. *Right-angled triangle:* (1) a right-angle or point with hypotenuse running diagonally across the arm on opposite side of field; (2) two acute angles and hypotenuse; (3) three sides with hypotenuse most obtrusive; (4) elongated pressure field pointed at one end and gradually wider at the other. *Diamond:* (1) two acute angles, the sides of which diverge so as to make a wide pressure area with unclear outline in center of field; (2) an elongated field with two points at extremes and a blurred area between; (3) four points or angles with completed or uncompleted sides. *Hexagon:* this was not identified often enough to allow us to speak of a mode by which it was generally apprehended. Most confusions of this figure were with the square and circle. In the several instances when it was reported accurately by the one *O*, a field of equal dimensions longitudinally and transversely but lacking long straight sides or right angles was perceived.

From the foregoing it is patent that acute angles are more potent landmarks for the tactual perception of the form of figures than side-lines, while the side-lines are more likely to be

[3]In an earlier study (this Journal, 31, 1920, 273 ff.) the visually salient features of such figures were pointed out.

apprehended and to figure in the realization of the form of a figure than obtuse angles, and quite as likely as right angles. Acute angles are perceived much more definitely than right and obtuse angles. Because of increased sensitivity, the parts of the figure applied toward the wrist were generally more clearly apprehended than the parts falling more proximally.

As to whether form is mediated primarily by peripheral or by central processes, our results do not shed very conclusive light. It is apparent that central factors are involved, in view of the fact that imagery is employed to complete the form of a figure incompletely given sensorily. But there were a few instances when *O* asserted positively that the form seemed completely given in sensory tactual processes. There were also a number of reports to the effect that the realization of sensory pressure and of a pressure field having definite outline were temporally disjoined. In all such cases, the apprehension of a 'pressure blur' preceded the realization of a pressure having a particular shape. But this temporal disjunction form of report was offset by reports, not nearly so frequent, that the perceptions of pressure and of shape came simultaneously. There were frequent instances, too, when in spite of instruction to observe form, *O* could only report a 'pressure blur,' as though some factor, perhaps central, failed for some reason to appear. The apprehension of pressure was quite generally more definite and unfailing than the perception of pressure having such and such shape. It is conceivable that our filled figures may at times have hindered or delayed the perception of shape, and that outline figures might have enabled us to determine, had time permitted, with more assurance the immediacy and the definiteness of the apprehension of shape.

Another indication of the possibility of central coöperation in the perception of form is the fact that all *O*s showed more or less pronounced daily sets for particular forms. On a given day the *O* would report one form much more accurately than the others and at a later sitting the same *O* manifested a similar pronounced tendency toward another form. On the same day, however, the *O* would also report the favored form for inappropriate figures. The temporary central predisposition seemed to tend both toward the accurate perception of the particular form for which a temporary set was assumed and toward the realization of that form even if a different stimulus was applied.

III. The Approximate Threshold of Size for the Perception of Form

The limen of form of several geometrical figures has already been determined by Major.[4] However, several points of differ-

[4]This Journal, 10, 1898, 143-147.

ence between his work and our own must be noted, if comparison is to be made. Major stimulated more sensitive parts of the skin surface, employed a method involving knowledge, and used only one of our figures—the equilateral triangle. He expresses the opinion that a procedure without knowledge should give "practically the same" limens as the procedure with knowledge.[5]

We arranged series of hard rubber stimuli of every one of our 5 figures for the purpose of making our determinations. In every series there were 5 stimuli having main dimensions, taken as given above, of 5, 10, 15, 20 and 25 mm. These were presented in haphazard order, the and *O*s were instructed to name the form of the impression occasioned by the stimulus. Table II

TABLE II

Form*	Judgment	Dimension 5 mm.	10 mm.	15 mm.	20 mm.	25 mm.
Square	Accurate	0	7	13	25	20
	Confused	0	0	25	33	40
	Inaccurate	0	13	28	30	23
	No Shape	100	80	33	12	17
Equil. Triangle	Accurate	0	10	25	27	22
	Confused	0	8	30	33	35
	Inaccurate	0	20	33	33	40
	No Shape	100	62	12	7	3
Right-Angled Triangle	Accurate	0	8	23	30	22
	Confused	0	12	28	27	35
	Inaccurate	0	18	30	33	33
	No Shape	100	62	18	10	10
Diamond	Accurate	0	3	13	23	25
	Confused	0	3	20	30	20
	Inaccurate	0	8	33	32	35
	No Shape	100	85	33	15	20

*Results for the Hexagon omitted because it was reported by one *O* only (Z), and by him only 5 times.

embodies the aggregate percentages of accurate, confused, inaccurate, and failure judgments of form given by the 4 *O*s. The results for the hexagon were again as unsatisfactory as in the previous work. It was reported correctly by only one *O* again, and all told in 5 instances only.

The stimuli of 5 and 10 mm. quite generally gave rise to the perception of a mere point or a blunt point of shapeless pressure. In the few instances when the forms of the 10 mm. stimulus were correctly reported, the shape was described as very indefinite and the judgment as essentially a guess. The minimal magnitude of stimulus for the passive apprehension of shape in the region stimulated seems to fall between 10 and 15 mm.

[5]*Idem*, 146.

The optimal dimension seems in general to be 20 mm. The accurate judgments of the 10 mm. stimulus in every case amounted to less than 50%, and those of the 15 mm. stimulus in every case to more than 50% of the accurate judgments of this optimal stimulus magnitude. Hence our conclusion that the liminal magnitude falls somewhere between the 10 mm. stimulus and the 15 mm. stimulus.

Conclusions

(1) Tactual form is not so definitely and unfailingly apprehended as tactual pressure when vision is excluded and the member kept passive during stimulation. Tactual pressure is invariably perceived, while tactual form is not definitely given in a considerable percentage of cases, and is not apprehended at all in an appreciable number of instances.

(2) The realization of form is minimal in cases of 'mere pressure blur,' where pressure totally devoid of outline or highlands of pressure boundary is apprehended; and maximal where the completed contour of a figure-form is given at all points in terms of the tactual impression. Between these extremes are intermediate degrees of definiteness of form, where salient topographical features of the tactual impression of a form are perceived in isolation (the contour being broken between these tactual highlands) that must be completed either in visual or in tactual imagery or in both to occasion the perception of the particular form.

(3) The stimuli of common geometrical figures must have a main dimension of 12 to 15 mm. to give rise readily to a tactual impression of determinate shape, if stimulation is made on the middle of the forearm. Impressions occasioned by stimuli of smaller main dimension are described as 'blunt points without contour,' 'shapeless pressure,' or 'mere sensory pressure stimulation.' The optimal main dimension for the mid-forearm by our method of stimulation is somewhat larger, about 20 mm.

THE EFFECT OF COLOR ON APPARENT SIZE AND WEIGHT

By Carl J. Warden and Ellen L. Flynn, University of Wisconsin

The present study is a preliminary attempt to determine the effect of color and arrangement on the apparent size and weight of a series of cartons, identical in actual size and shape, and differing only in the factor of color and serial position. The first experiment is concerned with the illusion of size (color-size illusion); the second with the illusion of weight (color-weight illusion).

The cartons used in the study were of cardboard, rectangular in form, measuring 16.5 cm. high, 9 cm. wide and 5.5 cm. deep. Eight of these boxes were used. They were covered respectively with red, yellow, green, blue, purple, white, grey and black Hering papers. The paper was stretched tightly and was so cut that no seams appeared on the sides toward *S*.

Inasmuch as the primary interest in the problem was practical, being connected with the display of merchandise, an attempt was made to duplicate the conditions of retail trade. The cartons were placed 5.5 cm. apart in a glassed light oak case which stood 4.5 ft. from the floor. They were placed directly against the back wall of the case, which was 4 in. from the glassed front, with the wider side (9 cm.) toward *S*.

The first serial arrangement of the cartons was made by chance. The succeeding arrangements, however, were obtained by a systematic rotation of the boxes from left to right so that every one became the initial member of the series. The immediate context of a given box, that is the color of the carton to the left and right, remained constant under all the arrangements except when it was either the initial or final member of the series. The 8 arrangements of the colored boxes were as follows:

Arrangement	Colors
A	Gy, Y, B, W, Bk, G, R, P
B	Y, B, W, Bk, G, R, P, Gy
C	B, W, Bk, G, R, P, Gy, Y
D	W, Bk, G, R, P, Gy, Y, B
E	Bk, G, R, P, Gy, Y, B, W
F	G, R, P, Gy, Y, B, W, Bk
G	R, P, Gy, Y, B, W, Bk, G
H	P, Gy, Y, B, W, Bk, G, R

Everyone of the 8 arrangements was ranked by 6 college students—3 men and 3 women. The final score for a given color is therefore the average of 48 rankings.

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